

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(7): 700-708
www.biochemjournal.com
Received: 21-04-2026
Accepted: 24-05-2026

MS Janbandhu
Ph.D. Scholar, Department of
Fruit Science, Dr. PDKV,
Akola (M.S), India

DM Panchbhai
Director of Instruction and
Dean, Faculty of Agriculture,
Dr. PDKV, Akola (M.S), India

Dr. SR Patil
Professor, Department of Fruit
Science, Dr. PDKV, Akola
(M.S), India.

Dr. SG Bharad
Head, Department of Fruit
Science, Dr. PDKV, Akola
(M.S), India.

Dr. MM Ganvir
Associate Professor,
Department of Agronomy,
AICRP for Dryland
Agriculture, Dr. PDKV, Akola
(M.S), India.

RD Walke
Associate Professor,
Department of Agricultural
Economics and Statistics, Dr.
PDKV, Akola (M.S), India.

VN Patil
Assistant Professor
(Horticulture), Bhausaheb
Fundkar Government College
of Agriculture, Buldhana, Dr.
PDKV, Akola (M.S), India.

Dr. NH Ramteke
Associate Professor,
Department of Fruit Science,
Dr. PDKV, Akola (M.S), India.

Corresponding Author:
MS Janbandhu
Ph.D. Scholar, Department of
Fruit Science, Dr. PDKV,
Akola (M.S), India

Effect of Different Physical and Chemical Treatments on Seed Germination and Seedling Growth in Charoli (*Buchanania lanzan* Spreng.)

MS Janbandhu, DM Panchbhai, SR Patil, SG Bharad, MM Ganvir, RD Walke, VN Patil and NH Ramteke

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i7Si.9078>

Abstract

The present investigation entitled “Effect of Different Physical and Chemical Treatments on Seed Germination and Seedling Growth in Charoli (*Buchanania lanzan* Spreng.)” was carried out during 2023–2024 at the Nursery Unit, Department of Fruit Science, Faculty of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment was laid out in a Factorial Randomized Block Design (FRBD) comprising two factors, twelve treatment combinations, and three replications. The different treatments evaluated were: T₁ (Scarification with ladle + GA₃ 200 ppm for 24 hours), T₂ (Scarification with ladle + GA₃ 300 ppm for 24 hours), T₃ (Scarification with ladle + NAA 200 ppm for 24 hours), T₄ (Scarification with ladle + NAA 400 ppm for 24 hours), T₅ (Scarification with 5% H₂SO₄ for 10 minutes + GA₃ 200 ppm for 24 hours), T₆ (Scarification with 5% H₂SO₄ for 10 minutes + GA₃ 300 ppm for 24 hours), T₇ (Scarification with 5% H₂SO₄ for 10 minutes + NAA 200 ppm for 24 hours), T₈ (Scarification with 5% H₂SO₄ for 10 minutes + NAA 400 ppm for 24 hours), T₉ (Stratification at 4 °C for 15 days + GA₃ 200 ppm for 24 hours), T₁₀ (Stratification at 4 °C for 15 days + GA₃ 300 ppm for 24 hours), T₁₁ (Stratification at 4 °C for 15 days + NAA 200 ppm for 24 hours), and T₁₂ (Stratification at 4 °C for 15 days + NAA 400 ppm for 24 hours). The results indicated that the synergistic combination in treatment T₆ (scarification with 5% H₂SO₄ for 10 minutes + GA₃ 300 ppm for 24 hours) was significantly superior to the other treatments. It recorded the minimum days to germination (9.33 days), maximum germination percentage (88.67%), highest survival rate (80.33%), maximum number of leaves (15.67), maximum stem diameter (4.47 mm), maximum seedling height (38.83 cm), highest plant fresh weight (23.67 g), and highest plant dry weight (13.02 g).

Keywords: Acid scarification, gibberellic acid (GA₃), plant propagation, pre-sowing treatments, seed dormancy, seed germination and seedling vigor

Introduction

Charoli (*Buchanania lanzan* Spreng.), which is also widely known as Chironji or Piyal, is a valuable fruit tree belonging to the Anacardiaceae family. The species originally originated from the Indian subcontinent. It was first documented by Francis Hamilton in 1798, and its valid scientific name was officially described in 1801 by the German botanist Kurt Sprengel (abbreviated as "Spreng." in the scientific name). Because of its immense ecological and economic value, this tree serves as an excellent option for social agroforestry, which integrates tree planting with local crops to benefit farming communities and support the environment. It assumes great significance due to its diverse uses and capacity to withstand adverse climatic conditions. At present, it grows under forest conditions as an underexploited fruit and provides monetary benefits to the tribal communities of the country. The kernels are highly nutritious, rich in protein (25–30%) and contain a sweet oil that can be used as a substitute for olive and almond oils. It is a medium-sized tree, reaching up to 40–50 feet in height with a straight trunk. The trees exhibit an alternate bearing habit, similar to mango. It flowers in the months of January and February and the fruits ripen in April and May. The kernels are of very high value and fetch Rs. 1800–2000 per kg in the market. In Vidarbha (Maharashtra), this species is found mainly in the Gadchiroli, Gondia, Amravati and Akola districts. Because charoli is a vulnerable plant, it is included in the Red Data Book published by the International Union for Conservation of Nature and Natural Resources (IUCN).

This species has high socioeconomic value, providing a livelihood to the tribal population and holds high potential as a commercial horticultural crop. Unfortunately, overexploitation and indiscriminate harvesting (lopping and cutting) pose a severe threat to it; hence, urgent conservation efforts are required at all levels.

Charoli seeds are recalcitrant in nature and lose viability in three months after harvesting (Chauhan *et al.*, 2020) ^[2]. They exhibit poor germination even when exposed to favorable conditions due to exogenous seed dormancy. This dormancy may be attributed to morphological factors, such as a hard, thick testa, or to incorrect storage and handling (secondary dormancy). Such seeds require special physical treatments, such as stratification or scarification to overcome dormancy. Furthermore, pre-sowing seed treatments with chemicals like GA₃, KNO₃ and NAA (Rajamanickam *et al.*, 2002) ^[14] have been reported to improve seed germination and seedling growth. To meet the local demand for quality charoli planting material, a field trial was conducted to find an effective seed treatment that facilitates the easy multiplication, regeneration and conservation of this important species.

Materials and Methods

The experiment was conducted during 2023-2024 at the Nursery Unit, Department of Fruit Science, Faculty of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The seed germination experiment was laid out in a Factorial Randomized Block Design (FRBD) having two factors with twelve treatment combinations and three replications. The different treatments viz., T₁ - (Scarification with ladle + GA₃ 200 ppm for 24 hours), T₂ - (Scarification with ladle + GA₃ 300 ppm for 24 hours), T₃ - (Scarification with ladle + NAA 200 ppm for 24 hours), T₄ - (Scarification with ladle + NAA 400 ppm for 24 hours), T₅ - (Scarification with 5% H₂SO₄ for 10 minutes + GA₃ 200 ppm for 24 hours), T₆ - (Scarification with 5% H₂SO₄ for 10 minutes + GA₃ 300 ppm for 24 hours), T₇ - (Scarification with 5% H₂SO₄ for 10 minutes + NAA 200 ppm for 24 hours), T₈ - (Scarification with 5% H₂SO₄ for 10 minutes + NAA 400 ppm for 24 hours), T₉ - (Stratification at 4 °C for 15 days + GA₃ 200 ppm for 24 hours), T₁₀ - (Stratification at 4 °C for 15 days + GA₃ 300 ppm for 24 hours), T₁₁ - (Stratification at 4 °C for 15 days + NAA 200 ppm for 24 hours), and T₁₂ - (Stratification at 4 °C for 15 days + NAA 400 ppm for 24 hours) were used in the research programme.

Table 1: Details of the physical and chemical treatments and their combinations

Factor A (Physical treatments)		Factor B (Chemical treatments)	
P1 Scarification with ladle		C1 GA ₃ 200 ppm (24 hours)	
P2 Scarification with H ₂ SO ₄ (5% for 10 minutes)		C2 GA ₃ 300 ppm (24 hours)	
P3 Stratification 4 °C (15 days)		C3 NAA 200 ppm (24 hours)	
		C4 NAA 400 ppm (24 hours)	

Sr. No.	Treatment Combinations
1	T ₁ Scarification with ladle + GA ₃ 200 ppm (24 hours)
2	T ₂ Scarification with ladle + GA ₃ 300 ppm (24 hours)
3	T ₃ Scarification with ladle + NAA 200 ppm (24 hours)
4	T ₄ Scarification with ladle + NAA 400 ppm (24 hours)
5	T ₅ Scarification with H ₂ SO ₄ (5% for 10 minutes) + GA ₃ 200 ppm (24 hours)
6	T ₆ Scarification with H ₂ SO ₄ (5% for 10 minutes) + GA ₃ 300 ppm (24 hours)
7	T ₇ Scarification with H ₂ SO ₄ (5% for 10 minutes) + NAA 200 ppm (24 hours)
8	T ₈ Scarification with H ₂ SO ₄ (5% for 10 minutes) + NAA 400 ppm (24 hours)
9	T ₉ Stratification 4 °C (15 days) + GA ₃ 200 ppm (24 hours)
10	T ₁₀ Stratification 4 °C (15 days) + GA ₃ 300 ppm (24 hours)
11	T ₁₁ Stratification 4 °C (15 days) + NAA 200 ppm (24 hours)
12	T ₁₂ Stratification 4 °C (15 days) + NAA 400 ppm (24 hours)

Fresh, fully ripened, uniform and disease-free charoli fruits were collected from the All India Coordinated Research Project (AICRP) for Dryland Agriculture, Dr. P.D.K.V., Akola. The seeds were manually extracted and washed thoroughly with water. Floating, nonviable and damaged seeds were carefully removed. The remaining viable seeds were shade-dried for one hour. Finally, healthy seeds of uniform size and weight were selected for the experiment.

Various physical treatments, such as scarification with a ladle, scarification with H₂SO₄ (5%) for 10 minutes and stratification at 4 °C for 15 days, were applied to the freshly extracted charoli seeds. The seeds were then dipped in solutions of gibberellic acid (GA₃) (200 ppm and 300 ppm) and naphthaleneacetic acid (NAA) (200 ppm and 400 ppm) for 24 hours before sowing.

After seed treatment, the seeds were shade-dried for 10 minutes and sown at a depth of 1 cm in 20 × 15 cm polythene bags. These bags were kept in a polyhouse. Bags contained a growth medium consisting of a 1:1:1 ratio of soil, farmyard manure (FYM) and sand. The bags were watered as needed. Observations for germination parameters

were recorded daily, while vegetative parameters were recorded monthly, starting from the date of seed sowing.

1. Days required for germination

The date of first plumule emergence was observed. The time elapsed between the date of sowing and the date of plumule emergence was recorded as the number of days required for germination.

2. Germination percentage (%)

The germination percentage was recorded at 30 days after sowing (DAS). It was calculated using the following formula:

$$\text{Germination percentage (\%)} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

3. Survival percentage (%)

The survival percentage was recorded at 365 days after sowing (DAS). It was calculated using the following formula:

$$\text{Survival percentage (\%)} = \frac{\text{Number of seedlings survived}}{\text{Number of seeds germinated}} \times 100$$

4. Number of leaves

The total number of leaves per plant was counted from ten randomly selected and tagged seedlings at 180 DAS. The mean value was computed and expressed as the average number of leaves per seedling.

5. Stem diameter (mm)

The stem diameter of ten randomly selected and tagged seedlings was measured at a height of 3 cm from the base using a Vernier caliper at 180 DAS. The mean value was computed and expressed in millimeters (mm).

6. Seedling height (cm)

The height of ten randomly selected and tagged seedlings was measured from ground level to the growing tip at 180 DAS. The mean value was computed and expressed as the average seedling height in centimeters (cm).

7. Fresh weight of plant (g)

At 180 days after sowing (DAS), ten randomly selected and tagged seedlings from each treatment were carefully uprooted and properly washed. The fresh weight of the entire plant (including both shoot and root systems) was measured immediately using an electronic balance. The average fresh plant weight was computed and expressed in grams (g).

8. Dry weight of plant (g)

Following the measurement of fresh weight, the same ten randomly selected and tagged seedlings were subjected to drying. The entire plants were dried in a hot air oven at 60–75 °C for 10 to 20 hours until a constant weight was achieved. The average dry plant weight was computed and expressed in grams (g).

The experimental data were subjected to statistical analysis using the analysis of variance (ANOVA) technique, as described by Panse and Sukhatme (1967) [11].

Result and Discussion

1. Days required for germination

The days required for germination in charoli was significantly influenced by the different physical and chemical treatments and their combinations (Table 2, Fig. 1). Among the physical treatments, the minimum days to germination (13.67 days) was recorded in P₂ (Scarification with 5% H₂SO₄ for 10 minutes), while the maximum (18.42 days) was observed in P₃ (Stratification at 4 °C for 15 days). Regarding the chemical treatments, C₂ (GA₃ 300 ppm for 24 hours) recorded the minimum days to germination (12.44 days), whereas C₃ (NAA 200 ppm for 24 hours) recorded the maximum (18.11 days). Among the treatment combinations, the minimum days to germination (9.33 days) was achieved in T₆ (Scarification with H₂SO₄ H₂SO₄ for 10 minutes + GA₃ 300 ppm for 24 hours), whereas the maximum (22.00 days) was recorded in T₁₁ (Stratification at 4 °C for 15 days + NAA 200 ppm for 24 hours).

The reduction in the number of days to germination might be due to H₂SO₄ (5%) scarification, which degraded the lignin and cellulose matrix of the hard, stony endocarp. It plays a key role in breaking physical dormancy and increasing permeability for water imbibition and gaseous exchange. On the other hand, GA₃ (300 ppm) may be associated with triggering the de novo synthesis of hydrolytic enzymes like alpha-amylase and proteases, where it could rapidly mobilize stored endosperm reserves into simple sugars and amino acids and accelerate radicle emergence, which might be the reason for the reduced number of days to germination. Similar results were found by Sharma (2016) [16], Joshi *et al.* (2017) [4], Chauhan *et al.* (2020) [2], Sharma *et al.* (2020) [17], Homeshvari *et al.* (2022) [3] and Prakash *et al.* (2025) [13] in charoli, Palepad *et al.* (2017) [10] in custard apple and Lalitha *et al.* (2020) [6] in aonla.

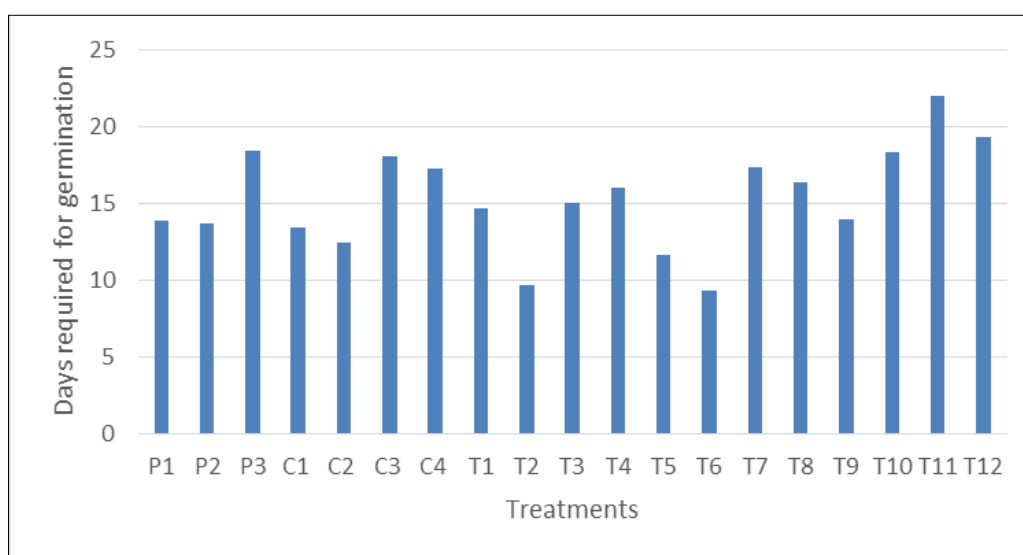


Fig 1: Effect of different physical and chemical treatments on days required for germination in charoli

2. Germination Percentage (%)

The germination percentage of the seedling in charoli was significantly influenced by the different physical and

chemical treatments and their combinations (Table 2, Fig. 2). Among the physical treatments, the highest germination percentage (77.25%) was recorded in P₁ (Scarification with

ladle), while the lowest (68.08%) was observed in P₃ (Stratification at 4 °C for 15 days). Regarding the chemical treatments, C₂ (GA₃ 300 ppm for 24 hours) recorded the highest germination percentage (86.00%), whereas C₃ (NAA 200 ppm for 24 hours) recorded the lowest (66.33%). Among the treatment combinations, the maximum germination percentage (88.67%) was achieved in T₆ (Scarification with H₂SO₄ 5% for 10 minutes + GA₃ 300 ppm for 24 hours), whereas the minimum (59.00%) was recorded in T₁₁ (Stratification at 4 °C for 15 days + NAA 200 ppm for 24 hours).

The increase in germination percentage might be due to H₂SO₄ scarification removing the mechanical resistance of the stony endocarp. It plays a key role in overcoming physical dormancy mechanisms and allowing unhindered embryo expansion. On the other hand, GA₃ (300 ppm) may

be associated with acting as a potent physiological catalyst to alter the endogenous promoter-to-inhibitor hormonal balance, where it could overcome Absciscic Acid (ABA) mediated suppression, promote cell division and elongation in the embryonic axis and ensure that a maximal number of embryos successfully break through the seed coat that might be the reason for the increased germination percentage. Similar results were found by Shukla and Solanki (2000)^[18], Narayan *et al.* (2014)^[9], Sharma (2016)^[16], Joshi *et al.* (2017)^[4], Sadashiv *et al.* (2017)^[15], Ajith *et al.* (2018)^[1], Chauhan *et al.* (2020)^[2], Sharma *et al.* (2020)^[17], Thounaojam and Dhaduk (2020)^[19], Khobragade *et al.* (2021)^[5], Homeshvari *et al.* (2022)^[3] and Prakash *et al.* (2025)^[13] in charoli, Vasantha *et al.* (2014)^[20] in tamarind and Palepad *et al.* (2017)^[10] in custard apple.

Table 2: Effect of different physical and chemical treatments on days required for germination and germination percentage in charoli

	Factor A (Physical treatments)	Days required for germination	Germination percentage (%)
P ₁	Scarification with ladle	13.83	77.25
P ₂	Scarification with H ₂ SO ₄ (5% for 10 min.)	13.67	72.83
P ₃	Stratification 4 °C (15 days)	18.42	68.08
	S.E (m) ±	0.16	0.36
	C.D. at 5%	0.46	1.07
	Factor B (Chemical treatments)		
C ₁	GA ₃ 200 ppm (24 hrs)	13.44	72.11
C ₂	GA ₃ 300 ppm (24 hrs)	12.44	86.00
C ₃	NAA 200 ppm (24 hrs)	18.11	66.33
C ₄	NAA 400 ppm (24 hrs)	17.22	66.44
	S.E (m) ±	0.18	0.42
	C.D. at 5%	0.54	1.23
	Treatment combinations		
T ₁	Scarification with ladle + GA ₃ 200 ppm (24 hrs)	14.67	77.67
T ₂	Scarification with ladle + GA ₃ 300 ppm (24 hrs)	9.67	87.33
T ₃	Scarification with ladle + NAA 200 ppm (24 hrs)	15.00	74.00
T ₄	Scarification with ladle + NAA 400 ppm (24 hrs)	16.00	70.00
T ₅	Scarification with H ₂ SO ₄ (5% for 10 min.) + GA ₃ 200 ppm (24 hrs)	11.67	66.67
T ₆	Scarification with H ₂ SO ₄ (5% for 10 min.) + GA ₃ 300 ppm (24 hrs)	9.33	88.67
T ₇	Scarification with H ₂ SO ₄ (5% for 10 min.) + NAA 200 ppm (24 hrs)	17.33	66.00
T ₈	Scarification with H ₂ SO ₄ (5% for 10 min.) + NAA 400 ppm (24 hrs)	16.33	70.00
T ₉	Stratification 4 °C (15 days) + GA ₃ 200 ppm (24 hrs)	14.00	72.00
T ₁₀	Stratification 4 °C (15 days) + GA ₃ 300 ppm (24 hrs)	18.33	82.00
T ₁₁	Stratification 4 °C (15 days) + NAA 200 ppm (24 hrs)	22.00	59.00
T ₁₂	Stratification 4 °C (15 days) + NAA 400 ppm (24 hrs)	19.33	59.33
	F Test	Sig	Sig
	S.E (m) ±	0.32	0.73
	C.D. at 5%	0.93	2.13

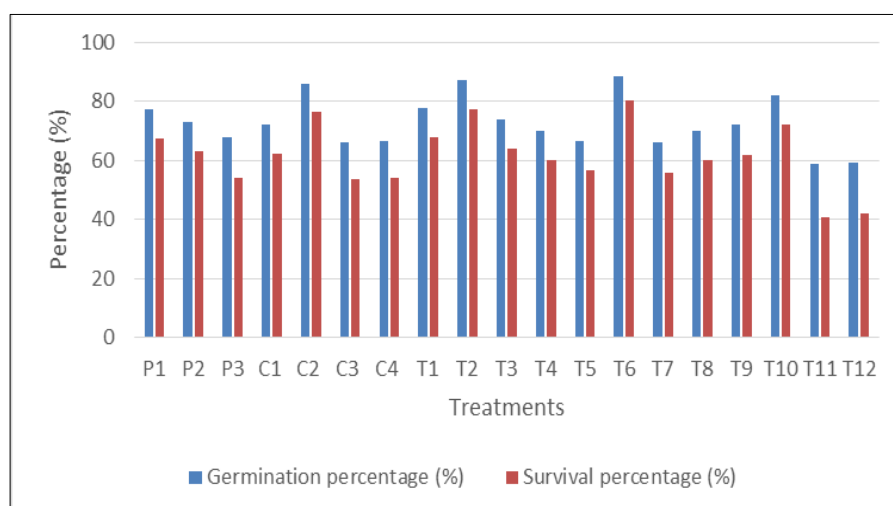


Fig 2: Effect of different physical and chemical treatments on germination percentage and Survival percentage in charoli

3. Survival Percentage (%)

The survival percentage of the seedling in charoli was significantly influenced by the different physical and chemical treatments and their combinations (Table 3, Fig. 2). Among the physical treatments, the highest survival percentage (67.25%) was recorded in P₁ (Scarification with ladle), while the lowest (54.17%) was observed in P₃ (Stratification at 4 °C for 15 days). Regarding the chemical treatments, C₂ (GA₃ 300 ppm for 24 hours) recorded the highest survival percentage (76.56%), whereas C₃ (NAA 200 ppm for 24 hours) recorded the lowest (53.56%). Among the treatment combinations, the maximum survival percentage (80.33%) was achieved in T₆ (Scarification with H₂SO₄ 5% for 10 minutes + GA₃ 300 ppm for 24 hours), whereas the minimum (40.67%) was recorded in T₁₁ (Stratification at 4 °C for 15 days+ NAA 200 ppm for 24 hours).

The increase in survival percentage might be due to H₂SO₄ (5%) scarification ensured that the emerging hypocotyl did

not exhaust its energy reserves struggling against a tough endocarp. It plays a key role in preserving cellular energy for immediate vegetative growth and providing early, robust and uniform germination for a competitive head start. On the other hand, GA₃ (300 ppm) may be associated with enhancing early cell elongation and metabolic activity in the hypocotyl and primary roots, where it could lead to the rapid establishment of a functional root system, efficient nutrient and water uptake and fortification against early-stage damping-off or environmental stress that might be the reason for the increased survival percentage. Similar results were found by Narayan *et al.* (2014)^[9], Joshi *et al.* (2017)^[4], Chauhan *et al.* (2020)^[2], Sharma *et al.* (2020)^[17], Homeshvari *et al.* (2022)^[3] and Prakash *et al.* (2025)^[13] in charoli, Manekar *et al.* (2011)^[8] and Lalitha *et al.* (2020)^[6] in aonla, Patel *et al.* (2017)^[12] in mango and Palepad *et al.* (2017)^[10] in custard apple.

Table 3: Effect of different physical and chemical treatments on survival percentage and number of leaves in charoli

	Factor A (Physical treatments)	Survival percentage (%)	Number of leaves
P ₁	Scarification with ladle	67.25	12.83
P ₂	Scarification with H ₂ SO ₄ (5% 10 min.)	63.25	12.58
P ₃	Stratification 4 °C (15 days)	54.17	10.50
	S.E (m) ±	0.32	0.16
	C.D. at 5%	0.94	0.48
	Factor B (Chemical treatments)		
C ₁	GA ₃ 200 ppm (24 hrs)	62.11	11.89
C ₂	GA ₃ 300 ppm (24 hrs)	76.56	14.56
C ₃	NAA 200 ppm (24 hrs)	53.56	10.44
C ₄	NAA 400 ppm (24 hrs)	54.00	11.00
	S.E (m) ±	0.37	0.19
	C.D. at 5%	1.08	0.56
	Treatment combinations		
T ₁	Scarification with ladle + GA ₃ 200 ppm (24 hrs)	67.67	12.67
T ₂	Scarification with ladle + GA ₃ 300 ppm (24 hrs)	77.33	14.67
T ₃	Scarification with ladle + NAA 200 ppm (24 hrs)	64.00	12.33
T ₄	Scarification with ladle + NAA 400 ppm (24 hrs)	60.00	11.67
T ₅	Scarification with H ₂ SO ₄ (5% for 10 min.) + GA ₃ 200 ppm (24 hrs)	56.67	11.33
T ₆	Scarification with H ₂ SO ₄ (5% for 10 min.) + GA ₃ 300 ppm (24 hrs)	80.33	15.67
T ₇	Scarification with H ₂ SO ₄ (5% for 10 min.) + NAA 200 ppm (24 hrs)	56.00	11.33
T ₈	Scarification with H ₂ SO ₄ (5% for 10 min.) + NAA 400 ppm (24 hrs)	60.00	12.00
T ₉	Stratification 4 °C (15 days) + GA ₃ 200 ppm (24 hrs)	62.00	11.67
T ₁₀	Stratification 4 °C (15 days) + GA ₃ 300 ppm (24 hrs)	72.00	13.33
T ₁₁	Stratification 4 °C (15 days) + NAA 200 ppm (24 hrs)	40.67	7.67
T ₁₂	Stratification 4 °C (15 days) + NAA 400 ppm (24 hrs)	42.00	9.33
	F Test	Sig	Sig
	S.E (m) ±	0.64	0.33
	C.D. at 5%	1.87	0.96

4. Number of Leaves

The number of leaves in charoli seedlings was significantly influenced by the different physical and chemical treatments and their combinations (Table 3, Fig. 3). Among the physical treatments, the highest number of leaves (12.83) was recorded in P₁ (Scarification with ladle), while the lowest (10.50) was observed in P₃ (Stratification at 4 °C for 15 days). Regarding the chemical treatments, C₂ (GA₃ 300

ppm for 24 hours) recorded the highest number of leaves (14.56), whereas C₃ (NAA 200 ppm for 24 hours) recorded the lowest (10.44). Among the treatment combinations, the maximum number of leaves (15.67) was achieved in T₆ (Scarification with H₂SO₄ 5% for 10 minutes + GA₃ 300 ppm for 24 hours), whereas the minimum (7.67) was recorded in T₁₁ (Stratification at 4 °C 15 days + NAA 200 ppm for 24 hours).

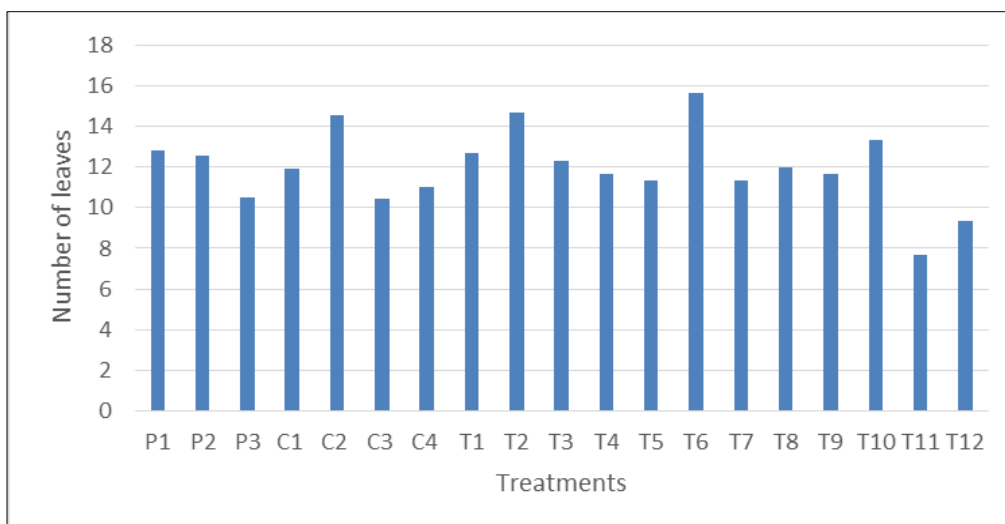


Fig 3: Effect of different physical and chemical treatments on number of leaves in charoli

The increase in the number of leaves might be due to H_2SO_4 (5%) scarification, which broke the mechanical seed barrier early. It plays a key role in transitioning the plant from heterotrophic to autotrophic growth much sooner. On the other hand, GA_3 (300 ppm) may be associated with stimulating cell division and elongation in the apical meristem, where it could lead to faster internodal development, earlier differentiation of leaf primordia, and enhanced nitrogen metabolism and chlorophyll synthesis that might be the reason for the increased number of leaves. Similar results were found by Sharma (2016) [16], Joshi *et al.* (2017) [4], Chauhan *et al.* (2020) [2], Sharma *et al.* (2020) [17], Mahadev *et al.* (2021) [7], Homeshvari *et al.* (2022) [3] and Prakash *et al.* (2025) [13] in charoli, Vasantha *et al.* (2014) [20] in tamarind, Palepad *et al.* (2017) [10] in custard apple and Lalitha *et al.* (2020) [6] in aonla.

5. Stem Diameter (mm)

The stem diameter of the seedling in charoli was significantly influenced by the different physical and chemical treatments and their combinations (Table 4, Fig. 4). Among the physical treatments, the highest stem diameter (3.80 mm) was recorded in P₁ (Scarification with ladle), while the lowest (3.22 mm) was observed in P₃ (Stratification at 0°C for 15 days). Regarding the chemical treatments, C₂ (GA_3 300 ppm for 24 hours) recorded the highest stem diameter (4.11 mm), whereas C₄ (NAA 400 ppm for 24 hours) recorded the lowest (3.19 mm). Among the treatment combinations, the maximum stem diameter (4.47 mm) was achieved in T₆ (Scarification with H_2SO_4 5% for 10 minutes + GA_3 300 ppm for 24 hours), whereas the minimum (2.80 mm) was recorded in T₁₁ (Stratification at 4 °C for 15 days + NAA 200 ppm for 24 hours).

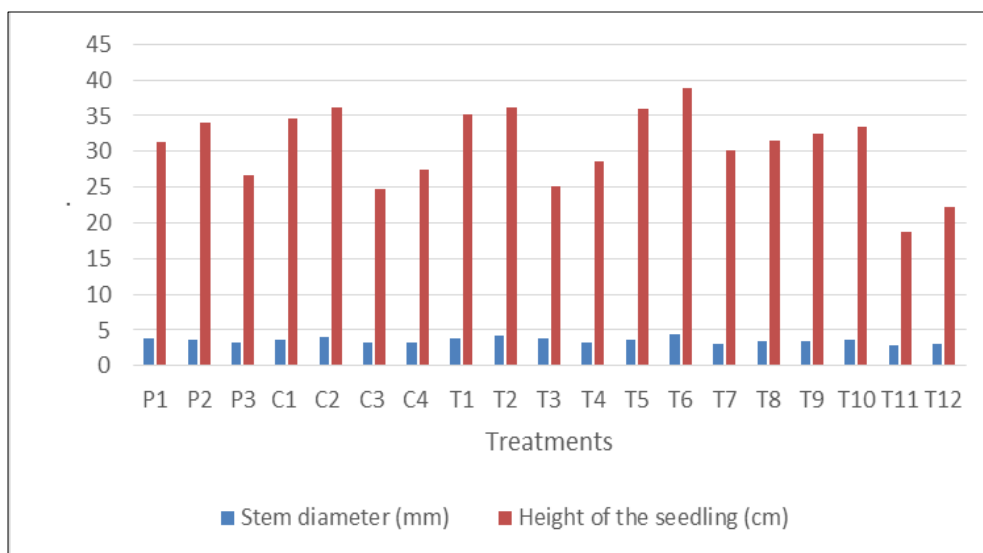


Fig 4: Effect of different physical and chemical treatments on stem diameter and height of the seedling in charoli

The increase in stem diameter might be due to H_2SO_4 (5%) scarification, which facilitated rapid germination and early establishment. It plays a key role in allowing the root system to uptake optimal soil nutrients, which structures the stem. On the other hand, GA_3 (300 ppm) may be associated with enhanced cambial activity, where it could develop a larger initial leaf area, generate abundant photo-assimilates and

promote radial cell division in the vascular cambium that might be the reason for increased stem diameter. Similar results were found by Sharma (2016) [16], Joshi *et al.* (2017) [4], Chauhan *et al.* (2020) [2], Sharma *et al.* (2020) [17] and Mahadev *et al.* (2021) [7] in charoli, Vasantha *et al.* (2014) [20] in tamarind, Palepad *et al.* (2017) [10] in custard apple and Lalitha *et al.* (2020) [6] in aonla.

6. Height of the Seedling (cm)

The height of the seedling in charoli was significantly influenced by the different physical and chemical treatments and their combinations (Table 4, Fig. 4). Among the physical treatments, the highest height of the seedling (34.11 cm) was recorded in P₂ (Scarification with 5% H₂SO₄ for 10 minutes), while the lowest (26.70 cm) was observed in P₃ (Stratification at 4 °C for 15 days). Regarding the chemical treatments, C₂ (GA₃ 300 ppm for 24 hours) recorded the highest height of the seedling (36.09 cm), whereas C₃ (NAA 200 ppm for 24 hours) recorded the lowest (24.66 cm). Among the treatment combinations, the maximum height of the seedling (38.83 cm) was achieved in T₆ (Scarification with H₂SO₄ 5% for 10 minutes + GA₃ 300 ppm for 24 hours), whereas the minimum (18.67 cm) was recorded in T₁₁ (Stratification at 4 °C for 15 days + NAA 200 ppm for 24 hours).

The increase in seedling height might be due to H₂SO₄ scarification enabled early and uniform emergence. It plays a key role in giving the seedling a longer total duration for active vegetative growth during the season. On the other hand, GA₃ may be associated with the alteration of plant cell wall plasticity, where it could drive extensive cellular elongation in the stem internodes and enhance the sink strength of the apical meristem that might be the reason for increased seedling height. Similar results were found by Sharma (2016) ^[16], Joshi *et al.* (2017) ^[4], Sadashiv *et al.* (2017) ^[15], Chauhan *et al.* (2020) ^[2], Sharma *et al.* (2020) ^[17], Khobragade *et al.* (2021) ^[5], Mahadev *et al.* (2021) ^[7], Homeshvari *et al.* (2022) ^[3] and Prakash *et al.* (2025) ^[13] in charoli, Vasantha *et al.* (2014) ^[20] in tamarind, Palepad *et al.* (2017) ^[10] in custard apple, Patel *et al.* (2017) ^[12] in mango and Lalitha *et al.* (2020) ^[6] in aonla.

Table 4: Effect of different physical and chemical treatments on stem diameter and height of the seedling in charoli

	Factor A (Physical treatments)	Stem diameter (mm)	Height of the seedling (cm)
P ₁	Scarification with ladle	3.80	31.26
P ₂	Scarification with H ₂ SO ₄ (5% 10 min.)	3.63	34.11
P ₃	Stratification 4 °C (15 days)	3.22	26.70
	S.E (m) ±	0.02	0.08
	C.D. at 5%	0.06	0.23
	Factor B (Chemical treatments)		
C ₁	GA ₃ 200 ppm (24 hrs)	3.69	34.52
C ₂	GA ₃ 300 ppm (24 hrs)	4.11	36.09
C ₃	NAA 200 ppm (24 hrs)	3.20	24.66
C ₄	NAA 400 ppm (24 hrs)	3.19	27.49
	S.E (m) ±	0.03	0.09
	C.D. at 5%	0.07	0.27
	Treatment combinations		
T ₁	Scarification with ladle + GA ₃ 200 ppm (24 hrs)	3.93	35.20
T ₂	Scarification with ladle + GA ₃ 300 ppm (24 hrs)	4.30	36.07
T ₃	Scarification with ladle + NAA 200 ppm (24 hrs)	3.77	25.20
T ₄	Scarification with ladle + NAA 400 ppm (24 hrs)	3.20	28.57
T ₅	Scarification with H ₂ SO ₄ (5% for 10 min.) + GA ₃ 200 ppm (24 hrs)	3.63	35.90
T ₆	Scarification with H ₂ SO ₄ (5% for 10 min.) + GA ₃ 300 ppm (24 hrs)	4.47	38.83
T ₇	Scarification with H ₂ SO ₄ (5% for 10 min.) + NAA 200 ppm (24 hrs)	3.03	30.10
T ₈	Scarification with H ₂ SO ₄ (5% for 10 min.) + NAA 400 ppm (24 hrs)	3.37	31.60
T ₉	Stratification 4 °C (15 days) + GA ₃ 200 ppm (24 hrs)	3.50	32.47
T ₁₀	Stratification 4 °C (15 days) + GA ₃ 300 ppm (24 hrs)	3.57	33.37
T ₁₁	Stratification 4 °C (15 days) + NAA 200 ppm (24 hrs)	2.80	18.67
T ₁₂	Stratification 4 °C (15 days) + NAA 400 ppm (24 hrs)	3.00	22.30
	F Test	Sig	Sig
	S.E (m) ±	0.04	0.16
	C.D. at 5%	0.13	0.47

7. Fresh Weight of Plant (g)

The fresh weight of the seedling in charoli was significantly influenced by the different physical and chemical treatments and their combinations (Table 5, Fig. 5). Among the physical treatments, the highest fresh weight (20.27 g) was recorded in P₂ (Scarification with 5% H₂SO₄ for 10 minutes), while the lowest (17.25 g) was observed in P₃ (Stratification at 4 °C for 15 days). Regarding the chemical treatments, C₂ (GA₃ 300 ppm for 24 hours)

recorded the highest fresh weight (22.27 g), whereas C₃ (NAA 200 ppm for 24 hours) recorded the lowest (15.41 g). Among the treatment combinations, the maximum fresh weight (23.67 g) was achieved in T₆ (Scarification with H₂SO₄ 5% for 10 minutes + GA₃ 300 ppm for 24 hours), whereas the minimum (14.07 g) was recorded in T₁₁ (Stratification at 4 °C for 15 days + NAA 200 ppm for 24 hours).

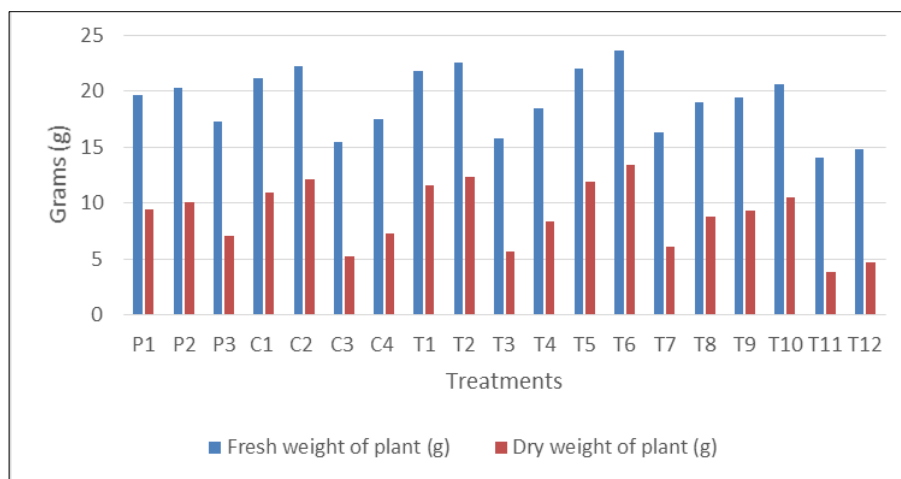


Fig 5: Effect of different physical and chemical treatments on fresh weight of plant and dry weight of plant in charoli

The increase in fresh weight might be due to H_2SO_4 scarification, which facilitated unhindered radicle emergence and the early development of a sprawling root system. It plays a key role in improving water and mineral uptake. On the other hand, GA_3 may be associated with increasing cellular volume and tissue hydration, where it could enhance overall morphometric traits such as plant

height, girth and leaf area that might be the reason for increased fresh weight. Similar results were found by Sharma (2016) ^[16], Mahadev *et al.* (2021) ^[7], Homeshvari *et al.* (2022) ^[3] and Prakash *et al.* (2025) ^[13] in charoli, Vasantha *et al.* (2014) ^[20] in tamarind, Palepad *et al.* (2017) ^[10] in custard apple and Lalitha *et al.* (2020) ^[6] in aonla.

Table 5: Effect of different physical and chemical treatments on fresh weight of plant and dry weight of plant in charoli

	Factor A (Physical treatments)	Fresh weight of plant (g)	Dry weight of plant (g)
P ₁	Scarification with ladle	19.67	9.48
P ₂	Scarification with H_2SO_4 (5% 10 min.)	20.27	10.08
P ₃	Stratification 4 °C (15 days)	17.25	7.08
	S.E (m) ±	0.01	0.02
	C.D. at 5%	0.04	0.05
	Factor B (Chemical treatments)		
C ₁	GA_3 200 ppm (24 hrs)	21.11	10.93
C ₂	GA_3 300 ppm (24 hrs)	22.27	12.09
C ₃	NAA 200 ppm (24 hrs)	15.41	5.21
C ₄	NAA 400 ppm (24 hrs)	17.46	7.28
	S.E (m) ±	0.02	0.02
	C.D. at 5%	0.05	0.05
	Treatment combinations		
T ₁	Scarification with ladle + GA_3 200 ppm (24 hrs)	21.83	11.63
T ₂	Scarification with ladle + GA_3 300 ppm (24 hrs)	22.53	12.33
T ₃	Scarification with ladle + NAA 200 ppm (24 hrs)	15.83	5.63
T ₄	Scarification with ladle + NAA 400 ppm (24 hrs)	18.47	8.33
T ₅	Scarification with H_2SO_4 (5% for 10 min.) + GA_3 200 ppm (24 hrs)	22.03	11.87
T ₆	Scarification with H_2SO_4 (5% for 10 min.) + GA_3 300 ppm (24 hrs)	23.67	13.47
T ₇	Scarification with H_2SO_4 (5% for 10 min.) + NAA 200 ppm (24 hrs)	16.33	6.13
T ₈	Scarification with H_2SO_4 (5% for 10 min.) + NAA 400 ppm (24 hrs)	19.03	8.83
T ₉	Stratification 4 °C (15 days) + GA_3 200 ppm (24 hrs)	19.47	9.30
T ₁₀	Stratification 4 °C (15 days) + GA_3 300 ppm (24 hrs)	20.60	10.47
T ₁₁	Stratification 4 °C (15 days) + NAA 200 ppm (24 hrs)	14.07	3.87
T ₁₂	Stratification 4 °C (15 days) + NAA 400 ppm (24 hrs)	14.87	4.67
	F Test	Sig	Sig
	S.E (m) ±	0.03	0.03
	C.D. at 5%	0.08	0.10

8. Dry Weight of Plant (g)

The dry weight of the plant in charoli was significantly influenced by the different physical and chemical treatments and their combinations (Table 5, Fig. 5). Among the physical treatments, the highest dry weight (10.08 g) was recorded in P₂ (Scarification with 5% H_2SO_4 for 10 minutes), while the lowest (7.08 g) was observed in P₃ (Stratification at 4 °C for 15 days). Regarding the chemical treatments, C₂ (GA_3 300 ppm for 24 hours) recorded the

highest dry weight (12.09 g), whereas C₃ (NAA 200 ppm for 24 hours) recorded the lowest (5.21 g). Among the treatment combinations, the maximum dry weight (13.47 g) was achieved in T₆ (Scarification with H_2SO_4 5% for 10 minutes + GA_3 300 ppm for 24 hours), whereas the minimum (3.87 g) was recorded in T₁₁ (Stratification at 4 °C for 15 days + NAA 200 ppm for 24 hours).

The increase in dry weight might be due to H_2SO_4 (5%) scarification, which caused an early physical breach of the

seed coat. It plays a key role in facilitating an advanced canopy structure for optimum light interception. On the other hand, GA₃ may be associated with the stimulation of cell division, cell elongation and auxin metabolism, where it could maximize the net assimilation rate, drive high rates of carbon fixation and optimize the source-sink dynamic that might be the reason for increased dry weight. Similar results were found by Sharma (2016) ^[16] and Homeshvari *et al.* (2022) ^[3] in charoli, Vasantha *et al.* (2014) ^[20] in tamarind, Palepad *et al.* (2017) ^[10] in custard apple, Patel *et al.* (2017) ^[12] in mango and Lalitha *et al.* (2020) ^[6] in aonla.

Conclusions

Based on the results of the present investigation entitled “Effect of Different Physical and Chemical Treatments on Seed Germination and Seedling Growth in Charoli (*Buchanania lanzan* Spreng.)”, It can be concluded that the seed treatment with 5% H₂SO₄ for 10 minutes followed by soaking in GA₃ at 300 ppm for 24 hours gave the earliest germination, the maximum germination percentage, optimum vegetative growth and the highest survival percentage of charoli seedlings.

References

1. Ajith S, Krishna V, Sudhesh L, Shastri RK. Dormancy breaking of stored seeds of *Buchanania lanzan* Spreng. (chironji), an endangered medicinal plant of the Western Ghats. J Emerg Technol Innov Res. 2018;5:2349-5162.
2. Chauhan PS, Sharma M, Pandey SBS, Bhatnagar P, Sharma MK, Nagar B. Effect of seed treatments on plus trees of *Buchanania lanzan* Spreng. in South-Eastern Rajasthan. J Pharmacogn Phytochem. 2020;9(4):301-303.
3. Homeshvari, Kanpure RN, Sahu DK, Nagar BL. Effect of different chemical and physical treatments on germination and seedling vigour of chironji (*Buchanania lanzan* Spreng.). Pharma Innov J. 2022;11(1):714-717.
4. Joshi CJ, Sharma DK, Mutteppa G, Rajni R. Effect of different chemicals on germination and seedling growth of chironji (*Buchanania lanzan* Spreng.). Plant Arch. 2017;17(2):1483-1486.
5. Khobragade ND, Rai N. Effect of pretreatments on seed germination and seedling growth of *Buchanania lanzan* Spreng. Pharma Innov J. 2022;11(1):104-106.
6. Lalitha KR, Tank RV, Chawla SL, Jena S. Effect of chemicals on seed germination and seedling growth of aonla (*Emblca officinalis* Gaertn.). Pharma Innov J. 2020;9(12):239-243.
7. Mahadev LP, Ahire DK, Kumar DB. Influence of different chemicals on vegetative growth of chironji (*Buchanania lanzan* Spreng.). IAR J Agric Res Life Sci. 2021.
8. Manekar RS, Sable PB, Rane MM. Influence of different plant growth regulators on seed germination and subsequent seedling growth of aonla (*Emblca officinalis* Gaertn.). Green Farming. 2011;2(4):477-478.
9. Narayan K, Patra HK, Dhruw SK. Standardization of propagation methods of charoli (*Buchanania lanzan* Spreng.). Asian J Hortic. 2014;9(1):283-284.
10. Palepad KB, Bharad SG, Bansode GS. Effect of seed treatments on germination, seedling vigour and growth rate of custard apple (*Annona squamosa* L.). J Pharmacogn Phytochem. 2017;6(5):20-23.
11. Panse VG, Sukhatme PV. *Statistical methods for agricultural workers*. 2nd ed. New Delhi: Indian Council of Agricultural Research; 1967.
12. Patel RJ, Ahlawat TR, Patel AI, Amarcholi JJ, Patel BB, Sharma K. Growth of mango (*Mangifera indica* L.) rootstocks as influenced by pre-sowing treatments. J Appl Nat Sci. 2017;9(1):582-586.
13. Prakash O, Srivastava AK, Gautam DK, Singh SC, Gangwar V, Kumar S, Prajapati P. Standardization of scarification and growing media for seed germination and seedling growth of chironji (*Buchanania lanzan* Spreng.). Indian J Hortic. 2025;82(4):433-439.
14. Rajamanickam C, Anbu S, Balakrishnan K. Effect of chemicals and growth regulators on seed germination in aonla (*Emblca officinalis* Gaertn.). South Indian Hortic. 2002;50(1-3):211-214.
15. Sadashiv D, Nimbalkar DS, Patil, Vitthal KK. Effect of seed treatment methods on germination and seed vigor of *Buchanania lanzan* Spreng. (charoli). Trends Biosci. 2017;10(27):5729-5732.
16. Sharma DK. Effect of plant growth regulators and scarification on germination and seedling growth of chironji (*Buchanania lanzan* Spreng.). Adv Life Sci. 2016;5(8):3237-3241.
17. Sharma M, Chauhan PS, Pandey SBS, Bhatnagar P, Sharma MK, Nagar B. Seed germination behaviour and seedling attributes of *Buchanania lanzan* (Spreng.) in South-Eastern Rajasthan. Pharma Innov J. 2020;9(1):123-128.
18. Shukla SK, Solanki KR. Studies on seed germination, plant survival and growth of chironji (*Buchanania lanzan* Spreng.). J Trop For. 2000;16(1):44-49.
19. Thounaojam AS, Dhaduk HL. Enhancement of seed germination in chironji (*Buchanania lanzan* Spreng.) through physical and chemical treatments. J Pharmacogn Phytochem. 2020;9(1):1354-1359.
20. Vasantha PT, Vijendrakumar RC, Guruprasad TR, Mahadevamma M, Santhosh KV. Studies on growth regulators and biofertilizers on seed germination and seedling growth of tamarind (*Tamarindus indica* L.). Plant Arch. 2014;14(1):155-160.